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ABSTRACT

In recent years there has been a strong interest on the part of universities, particularly in Latin America and Southeast Asia, to increase the percentage of their engineering faculty with doctoral degrees. Since there are relatively few doctoral programs in engineering in these countries, many universities would like to upgrade their current faculty by encouraging them to obtain doctoral degrees from nationally ranked schools in the U.S. or Europe. Unfortunately, given their teaching workloads and faculty shortages it is extremely difficult for these universities to grant their faculty a protracted leave of absence of four or more years to complete their education abroad. In this paper, authors present and discuss alternative models for doctoral programs designed for such faculty, that are flexible enough to accommodate their unique circumstances while at the same time maintain academic rigor. The key factors enabling such an approach are the growth in distance-education technology, the Internet and sophisticated means of rapid and interactive communications. Authors detail a number of academic issues, along with several alternative strategies for the actual delivery of these programs. A typical doctoral program is dissected into its components and models for flexible programs within each are detailed. Finally, a model program developed at the University of Pittsburgh is described. (Author)

Flexible Doctoral Programs for International Faculty

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Abstract *- In recent years there has been a strong interest on the part of universities, particularly in Latin America and Southeast Asia, to increase the percentage of their engineering faculty with doctoral degrees. Since there are relatively few doctoral programs in engineering in these countries, many universities would like to upgrade their current faculty by encouraging them to obtain doctoral degrees from nationally ranked schools in the U.S. or Europe. Unfortunately, given their teaching workloads and faculty shortages it is extremely difficult for these universities to grant their faculty a protracted leave of absence of four or more years to complete their education abroad. In this paper we present and discuss alternative models for doctoral programs designed for such faculty, that are flexible enough to accommodate their unique circumstances while at the same time maintain academic rigor. The key factors enabling such an approach are the growth in distance-education technology, the Internet and sophisticated means of rapid and interactive communications. We detail a number of academic issues, along with several alternative strategies for the actual delivery of these programs. A typical doctoral program is dissected into its components and models for flexible programs within each are detailed. Finally, a model program developed at the University of Pittsburgh is described.*

Introduction

The last decade has witnessed rapid technological growth across the globe and this growth has included many developing economies in Southeast Asia such as Thailand, Indonesia, Malaysia and Singapore, and in Latin America such as Mexico, Brazil, Argentina, Colombia, Chile and Peru. As the economies in these regions have expanded, they have fueled a rapid increase in the demand for well-educated engineers and scientists who are familiar with the latest technological advances. The supply of highly qualified engineers has typically lagged behind this demand though governments, universities and the private sector have all increased their investments in technology and in the education and training of the technological workforce. One of the reasons for this is that (with notable exceptions), universities and centers of higher learning in the regions mentioned above often do not have faculties qualified in the latest technologies, as in the research-based institutions in the United States or Europe. In many of these universities, the fraction of the engineering faculty with Ph.D. degrees is small and many faculty members tend to possess no more than a Master's degree. Although such faculty usually have significant experience and a very good understanding of the work environment and other factors that may be unique to their own country, the lack of doctoral degrees has typically limited the career paths of the faculty and their ability to educate engineers in leading-edge technologies. Consequently, there has been a strong interest on the part of many universities, particularly in Latin America and Southeast Asia, to increase the percentage of their engineering faculty with doctoral degrees and advanced training so that they may enhance their personal and professional development, and in turn provide their students with the latest tools and techniques.

Background

Unfortunately, few universities in these countries offer doctoral programs in engineering. Given this lack of internal means for providing potential engineering faculty with effective advanced training, many universities try to attain high faculty quality by attempting to hire their citizens who have earned Ph.D. degrees from good universities overseas in countries such as the U.S., Canada, Britain, France or Germany. However, this approach is not always feasible since such graduates tend to take jobs overseas and not return home after completing their doctoral studies. Moreover, the pool of such candidates is often very small and the universities must compete with each other as well as with industry in order to attract them. Among many such universities, an alternative that is being actively explored is one where their current faculty are upgraded by encouraging them to obtain doctoral degrees from nationally ranked schools in the U.S. or Europe.

However, given their shortage of high-quality faculty and the high teaching workloads that such faculty typically have, it is extremely difficult for these universities to grant their faculty a protracted leave of absence of four or more years to complete their education abroad. Moreover, many mid-career faculty members have been in their appointments for several years and find it difficult to uproot their families and live as graduate students for relatively long intervals of time. A natural solution to this problem is for U.S. and European universities to develop flexible doctoral programs that are specifically designed for such faculty. Such programs must be flexible enough to accommodate their unique circumstances but must simultaneously maintain academic rigor. Based on an informal preliminary survey

that the authors have conducted, there is strong interest in such programs from international faculty in a number of universities (e.g., ITESM and CETYS in Mexico, Universidad de los Andes in Colombia, Kasetsart and Chulalongkorn Universities in Thailand, to name a few). Additionally, there is also some interest from faculty at U.S. and Canadian universities that are focused primarily on teaching. Another fact that emerged based on these surveys is that there are no organized initiatives of this sort within the U.S. although some universities in the U.K. (e.g., University of Nottingham) do seem to have such programs. However, the model for British doctoral programs is quite different from a U.S. one in that it requires little or no formal coursework, thus making it easier to adapt.

In contrast with the situation in the past, there are several key factors today that make it feasible to have graduate programs with the characteristics mentioned above. These include recent advances in distance-education technology that incorporate sophisticated means of rapid and interactive communications, the development of the Internet, the explosive growth in information and the ability to rapidly move large volumes of information across thousands of miles, and the development of highly sophisticated computer systems and software. These factors significantly reduce the need for face-to-face, personal interactions and allow for study at a remote location. Geographic boundaries are really not a limitation any longer and increasingly, educational content is being delivered to students as opposed to having students physically go to a university to obtain this education. Indeed, this observation is borne out by the rapid growth in distance education programs at a number of well-known universities, as well as entire "virtual" universities such as the Open University in the U.K. and the University of Phoenix in the U.S. Typically, such programs are at the undergraduate (or in some cases, the Master's) level and are not aimed at the traditional market of college age people, but rather at more mature individuals who are already in the workforce.

It should be emphasized at this point that the nontraditional programs described in the previous paragraph are not meant to, and never will replace traditional university degree programs. Rather, they represent the use of modern technology to effectively address the needs of a section of the population that would otherwise be unable to avail itself of the opportunity for a college degree. Clearly, this is easier to do at the undergraduate level where advanced skills and specialization are not as important as in postgraduate programs. This also explains the fact that there are relatively few nontraditional Master's programs and none at the doctoral level. Indeed, it would be impossible to have a doctoral program without *any* direct contact between student and faculty, and a top quality doctoral program will certainly be one where the entire program is completed in residence at a university. However, it is quite conceivable that a high quality program could be developed that reduces the residence requirements while at the same time maintains the academic rigor of a traditional program. Such programs would satisfy a very real market need without sacrificing quality. This is the main issue addressed in this paper. We first take a typical doctoral program in engineering and dissect it into its components. A model for a flexible program that accounts for each component is then detailed. Finally, a specific example of a program at the University of Pittsburgh is described.

Components of a Typical Doctoral Program

A typical engineering doctoral program (for a student with an undergraduate degree who is interested in pursuing a Ph.D.) is made up of the following components:

1) *Preliminary Coursework*: On average this stage entails approximately 30 credits of coursework and tends to take between one and two years. The coursework typically covers basic graduate level material that is required of all doctoral students. It tends to be broad and ensures that the student is conversant with a variety of different areas within his or her field of study. Students who possess a Master's degree can often get transfer credit for significant portions of the coursework required here. This stage prepares the student for the next and very critical step.
2) *Qualifying Examination*: Most doctoral programs have a qualifying examination that is given 18 to 24 months into the program. This is usually a rigorous test of the student's preparedness for proceeding with his or her doctoral work and may have both an oral and a written component. It is used to ensure that the student has the breadth of skills necessary for a doctoral degree, as well as the ability to conduct more specialized study and research.
3) *Advanced Coursework*: This portion typically takes up 20 to 25 credits of course-work and the objective here is for the student who has passed the qualifying examination to immerse himself or herself in studying advanced topics in a chosen area of specialization. Usually this coursework can be completed in about a year or a year and a half. While the student is at this stage he or she is also expected to build a relationship with a faculty mentor and start to conduct some preliminary research in the chosen area of specialization in an attempt to clearly define a topic for the doctoral dissertation.
4) *Proposal Presentation*: Between two to three years into the program the student typically presents to an examination committee a proposal for a research topic. Usually the student would have completed some preliminary work and obtained some results that validate the topic and attest to the fact that it is worth pursuing further. The student defends the proposal and enlists the help of the committee members in more clearly defining the scope of the research so that it has sufficient depth while remaining feasible over a reasonable time-frame.
5) *Comprehensive Examination*: This is the second major exam faced by the student and is very often combined with the proposal presentation. The student's

committee gives this examination to ensure that he or she has enough knowledge and depth in the area of specialization to be able to conduct cutting-edge research. Any deficiencies identified are usually made up with recommendations for specific coursework or projects.

6) *Completion of Research*: This is the major stage of the student's doctoral career and lasts between a year and a half and two years on average. Usually, most coursework is complete by the time this stage commences and the student is immersed full-time in conducting research.
7) *Write-up and Final Defense*: Finally, in the last stage of the student's doctoral program the results of the research are collated and written into a dissertation which is then presented to an open audience and defended in front of the student's examining committee. The committee typically recommends some corrections or additional work before it is fully satisfied; however, if the student has received careful guidance this tends to be of a fairly minor nature. The writing of the dissertation can take from three to six months and a fair amount of it is done concurrently with the final stages of actual research.

It should be emphasized that the model described above is certainly not universal. Different programs have their own unique requirements (e.g., a foreign language) and there may be minor differences in the exact sequence of events as well. However, the above model is very typical of most engineering doctoral programs in the U.S. Beyond an undergraduate degree the whole process could last anywhere between four and seven years; in most instances, it may be expected to be about five years long.

Adapting to a Nontraditional Program

We now consider a nontraditional doctoral student such as the ones described earlier. Ideally, this would be a faculty member at an international university who has a Master's degree and several years of teaching and/or field experience. We now describe how the various components of a typical doctoral program could be adapted to accommodate such an individual. First, it would seem logical that this individual would be able to obtain credit for most of the basic coursework that is taken at the first stage, especially if he or she has been teaching courses in this area. Thus, for the most part the only coursework that would be required would be the advanced material and it should be feasible to complete this in one to one and a half years at the U.S. institution. This would also take care of the residency requirements (typically, one year) that most doctoral programs have for their doctoral students. The student would still have to take and pass the qualifying examination. This examination is typically given only once a year and ideally, it should be taken with the other doctoral candidates in the program, but if the logistics dictate otherwise the exam might have to be scheduled separately for the nontraditional student. An important issue to be resolved would be the definition of a suitable research topic. This requires active communication with a faculty member and being able to do this in a one year period represents a significant challenge for the student. However, given the fact that the nontraditional students can be expected to be somewhat more mature than the typical ones, this should be feasible. The student would have to be on site for the proposal presentation and the comprehensive examination which would be similar to those faced by the traditional student. Once this hurdle is crossed there is no inherent reason for the student to be physically present in the U.S. while he or she is carrying out the actual research. Of course, the topic of research would have to be one that allows itself to be conducted elsewhere - this would for instance, rule out research that is highly experimental in nature and require extensive use of specialized equipment that may not be available elsewhere. The student would have to be in constant contact with his or her adviser via e-mail, the Internet and / or distance-learning based technologies and it is conceivable that some short trips might be required to address important issues as they arise, as well to finalize details before the final defense. Ideally, it would be highly desirable for the student to spend the last semester before graduation in the U.S.; however, this is not necessarily imperative. The student would of course have to be physically present for the final dissertation defense.

In summary, it is quite feasible for a student to complete the program without being physically present for more than a year to eighteen months as long as a suitable dissertation topic is carefully selected and the student remains in constant contact with his or her academic adviser. Both of these are not difficult to accomplish. Finally, there is no reason why the student has to spend the entire year or eighteen months in the U.S. at one stretch. In fact an ideal way to do it would be to spend a full year initially, taking courses and refining the proposal, and then spend the last four months putting the finishing touches to the work and defending the dissertation. In the interim, it would also probably be desirable for the student to make a couple of brief visits (e.g., over the summer, or between semesters at his or her home institution) to address any urgent issues as they arise and to ensure that the entire program is on course.

A Sample Ph.D. Program in Industrial Engineering

We conclude with a brief outline of the doctoral program in Industrial Engineering (IE) at the University of Pittsburgh (Pitt) and discuss how this could be adapted to accommodate a nontraditional student. The requirements for a Ph.D. in IE at Pitt are straightforward. To be accepted into the doctoral program, a graduate student must have a superior scholastic graduate record and show promise for independent research, and a cumulative quality point average of 3.3 or better in graduate coursework. The candidate is required to spend at least one academic year full-time on campus, and is required to take a total of 72 credits beyond the undergraduate level; a student who already has a Master's

degree is permitted to transfer up to 30 credits of coursework. Out of the 72 credits, 18 credits are allocated to the dissertation and the remaining 54 to coursework. There are some specific requirements for the coursework. These include

- 18 credits of core courses: Operations Research, Manufacturing Systems, Information Systems, Systems Management, two courses in Statistics.
- 6 credits of additional coursework: a course in Simulation, and at least one course in Linear Optimization or Stochastic Processes.
- 30 credits of elective coursework of which at least nine credits must be from courses at the 3000 level (advanced, doctoral courses) and up to nine credits may come from courses outside the department.

The Ph.D. qualifying examination is given in January of each year and covers the core courses plus an open-ended unstructured problem. Students who do satisfactorily in the written examination are then permitted to take an oral examination. Both of these examinations which assess the student's ability to conduct doctoral-level research must be passed in order to be formally admitted to the doctoral program. After this the doctoral student specializes in one of the department's concentration areas and takes whatever courses may be required in preparation for the Ph.D. comprehensive examination and the student's dissertation topic. These courses are selected in conjunction with the program approved by the student's academic advisor. The comprehensive examination is taken by students after completing the course work in the area of concentration and is combined with the dissertation proposal. The dissertation topic is selected by the student, in consultation with a faculty advisor, in some theoretical or applied area of interest. Before the student embarks on dissertation research, the dissertation proposal must be approved by faculty committee comprising at least three graduate faculty members from within the department and one from outside the department. The final defense is open to the public and the final decision on the acceptability of the dissertation is made by the student's faculty committee.

One possible sequence of events for a nontraditional doctoral to satisfy the above requirements may is now detailed. First, we assume that the candidate has a Master's degree and has taken most, if not all, of the core courses. Conservatively, suppose that the candidate is able to transfer a total of 24 out of the maximum allowable 30 credits. This leaves an additional 30 credits of coursework to be completed, i.e., ten courses. If the student arrives at Pitt in the Fall he or she could take 4 courses in Fall and prepare for the qualifying examination in January. In fact, given the critical nature of the examination this preparation could even begin before the student arrives at Pitt. After passing the examination in January the candidate would take four courses in the Spring term and another two in the summer term. Simultaneously the candidate would also begin to build a relationship with a faculty member and start exploring areas of research for a suitable dissertation topic. Upon returning home after the one year stay, the candidate would stay in touch with the faculty adviser at Pitt and over the course of the next year further refine the research topic. During the next summer (or at another time that is suitable for the candidate) he or she would return to Pitt for a brief period to present the proposal and take the comprehensive examination. After this the candidate would return home and continue work on the dissertation research while staying in constant touch with the academic adviser and other members on the examining committee at Pitt. This phase can be expected to last two or more years and it is conceivable that the candidate may pay one or more short visits whenever convenient. Finally, the student would again come to Pitt full-time for a period of one term (four months) when he or she is ready to graduate and after spending the term finishing up all the details that go with the dissertation, would present and defend the same. The entire length of such a program would be the same four to five years as a regular program, except that the time spent on courses is only about one year, while that devoted solely to research is a little more than that of a traditional student. Figure 1 below shows a possible time-line for the program.

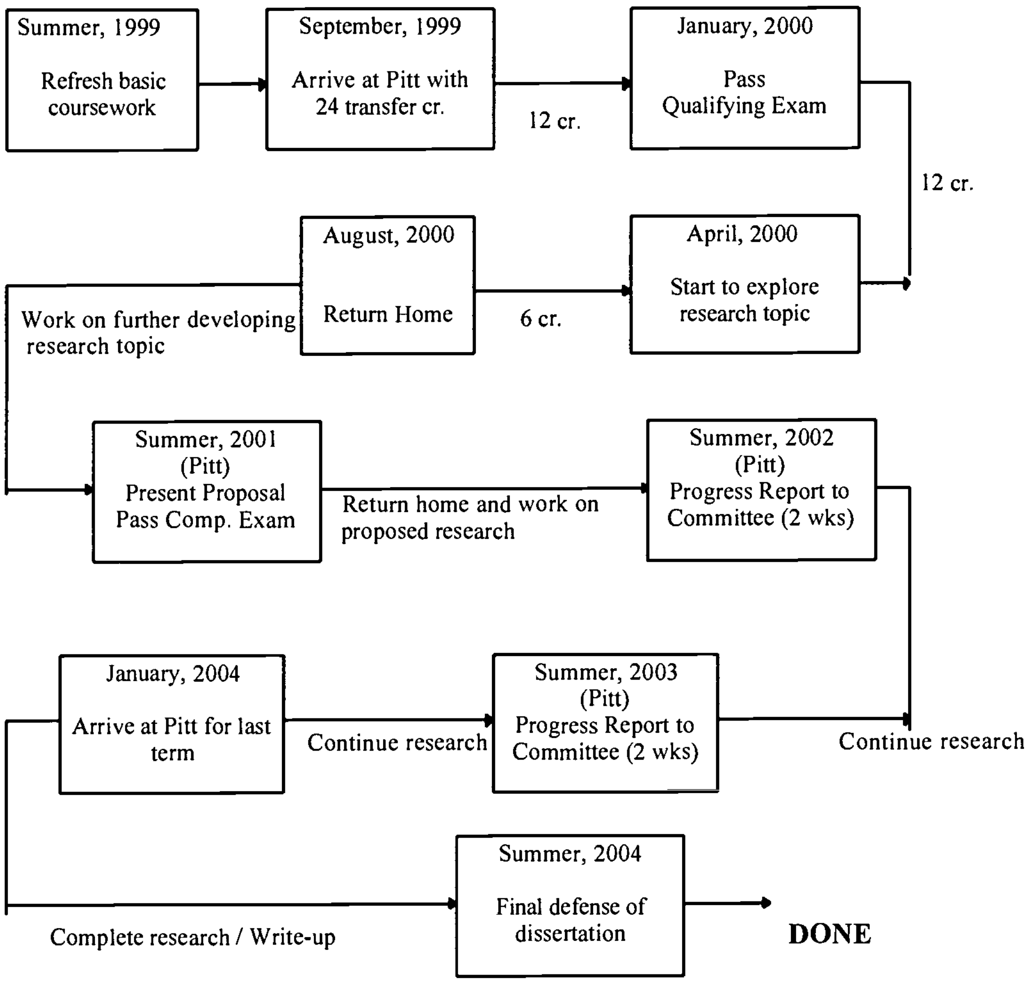

Figure 1: Time-Line for a Sample Program

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